Investigating Tool Wear and Surface Quality in Hard Turning

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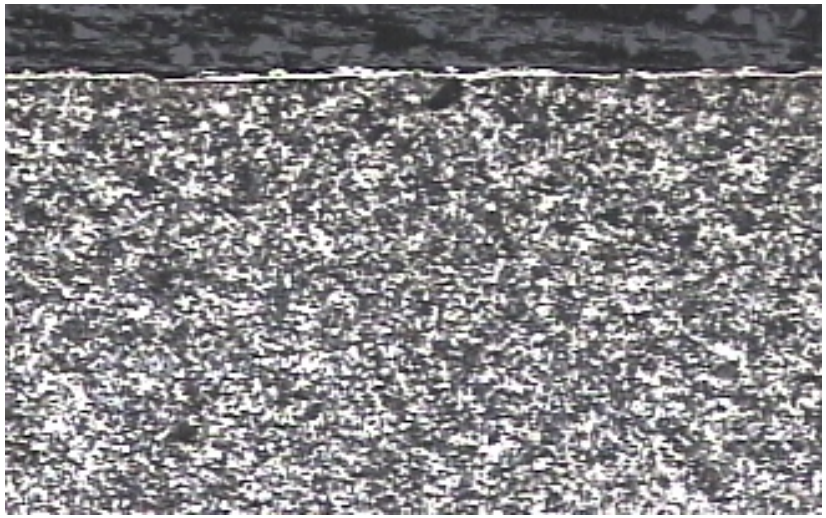
Research Objective

- Determine the effect of varying cutting conditions
  - cutting forces
  - tool wear
  - “white layer”
  - surface finish

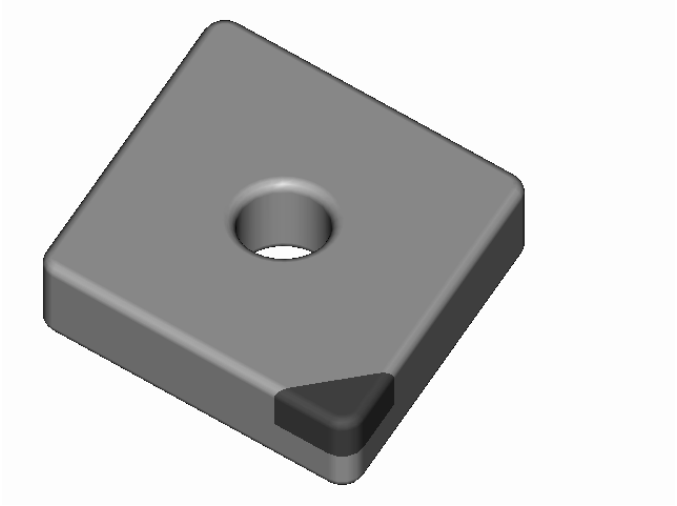


Test Matrix

Test #	Speed (m/min)	Feed (mm/rev)	DOC (mm)	Hardness HRC	Tool Material
1	182.9	0.152	0.203	58	'A' High CBN
2	182.9	0.076	0.203	58	'A' High CBN
3	91.4	0.152	0.203	58	'A' High CBN
4	91.4	0.152	0.203	58	'A' High CBN
5	182.9	0.152	0.203	62	'A' High CBN
6	182.9	0.152	0.508	62	'A' High CBN
7	182.9	0.076	0.508	62	'A' High CBN
8	91.4	0.152	0.508	62	'A' High CBN
9	182.9	0.152	0.203	62	'A' Low CBN
10	182.9	0.076	0.203	62	'A' Low CBN
11	91.4	0.152	0.203	62	'A' Low CBN
12	182.9	0.152	0.203	62	'B' High CBN
13	182.9	0.152	0.203	62	'B' Low CBN

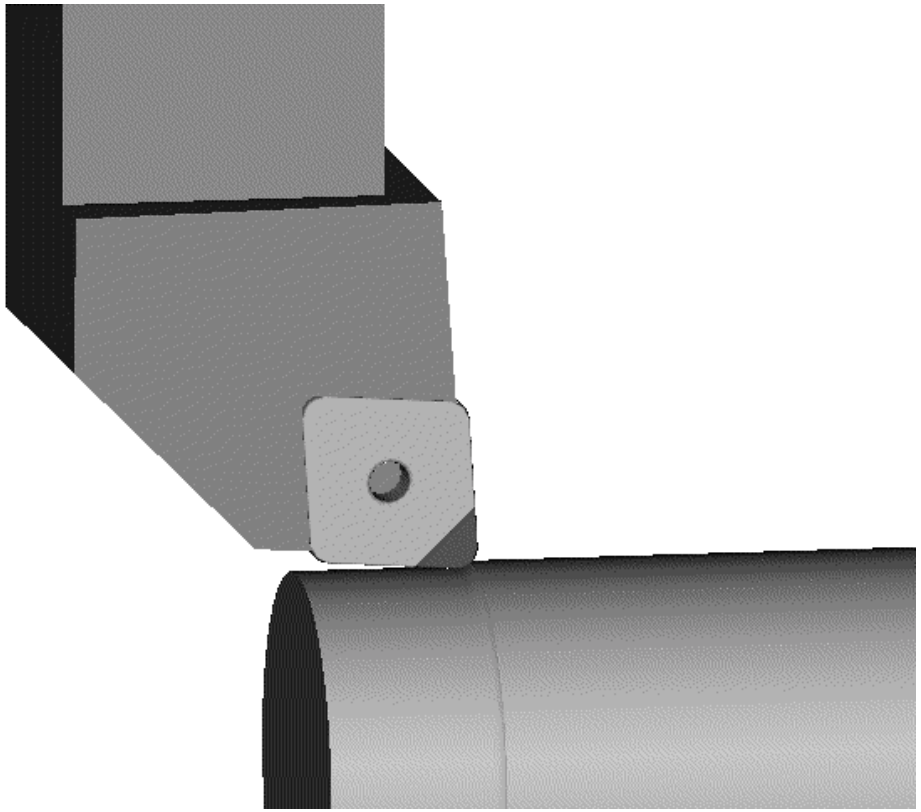
Cutting Tool

- Kennametal and Sumitomo CBN inserts
  - 80° diamond shape
  - 20° edge chamfer, 0.004” wide
  - Mini-tip CBN brazed to the carbide tool
- CBN grades
  - High CBN content designed for roughing
  - Lower CBN content designed for finishing conditions



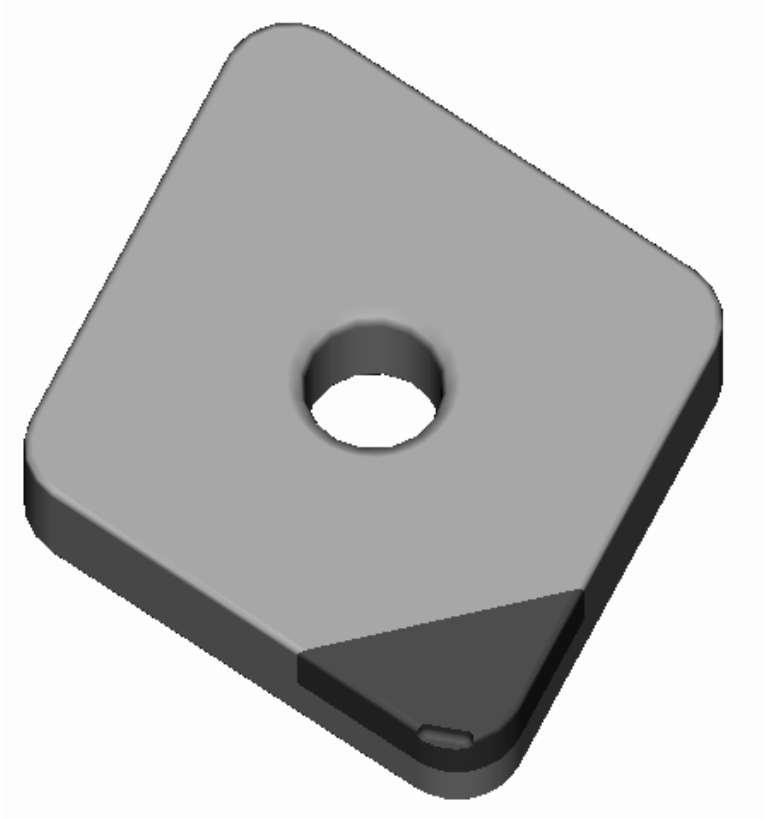
Turning Bar

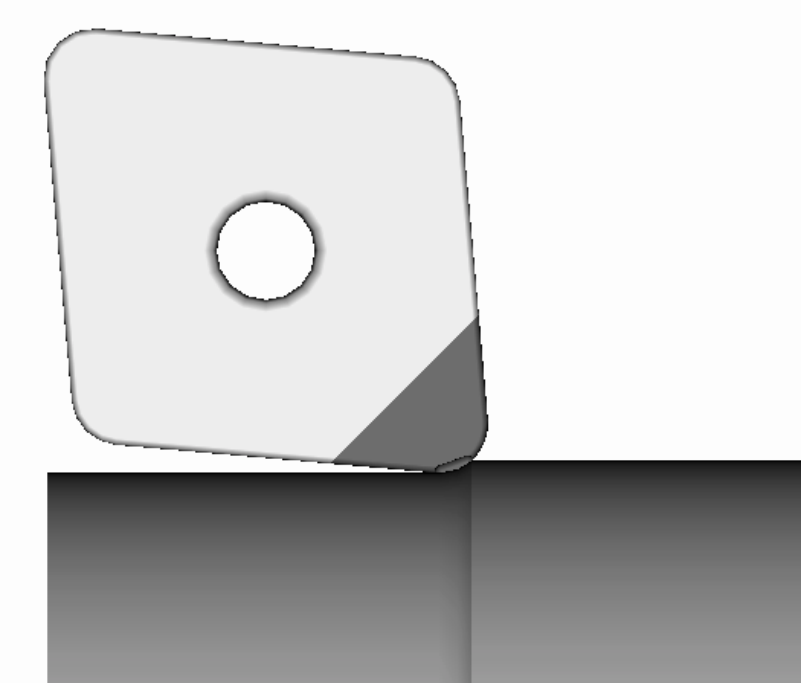
- Kennametal DCLNR-164D
  - 5° lead angle
  - Negative 5° side rake and back rake



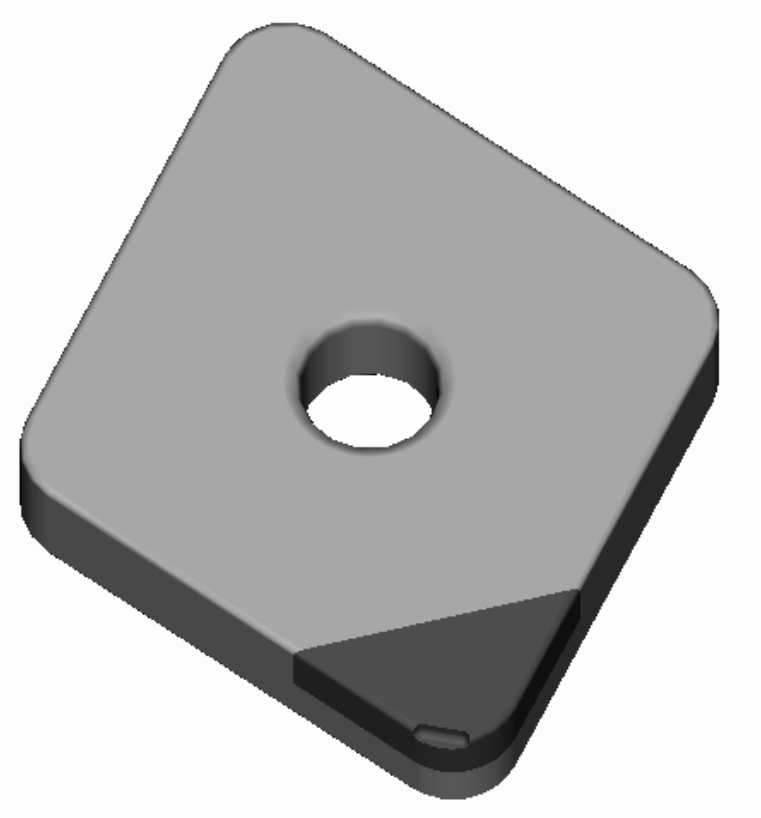
Tool Wear Results

- Tool wear occurs on nose radius of the tool
- At a 0.203mm (0.008”) depth of cut, the cut also occurs primarily on the 20° chamfer



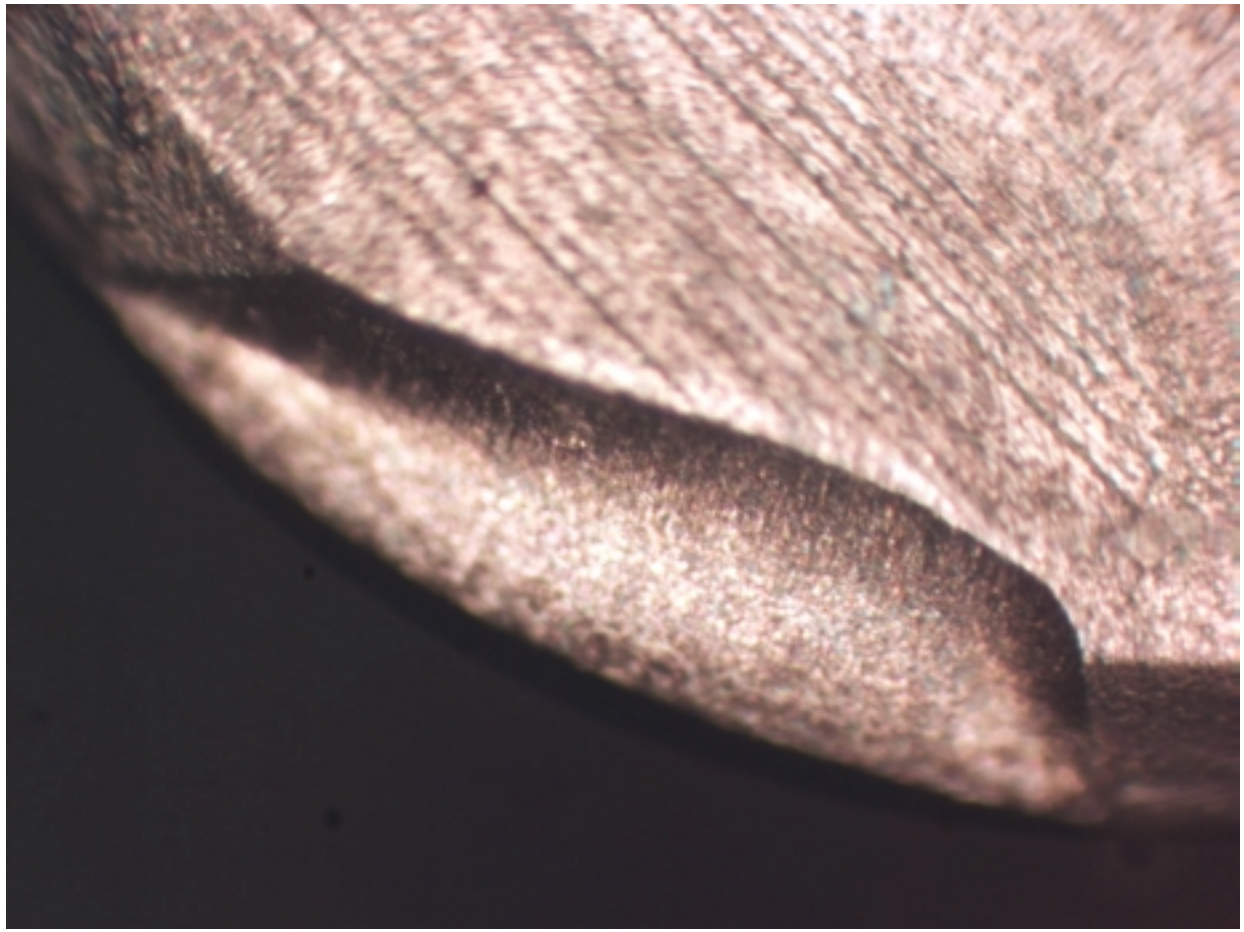


Crater Wear

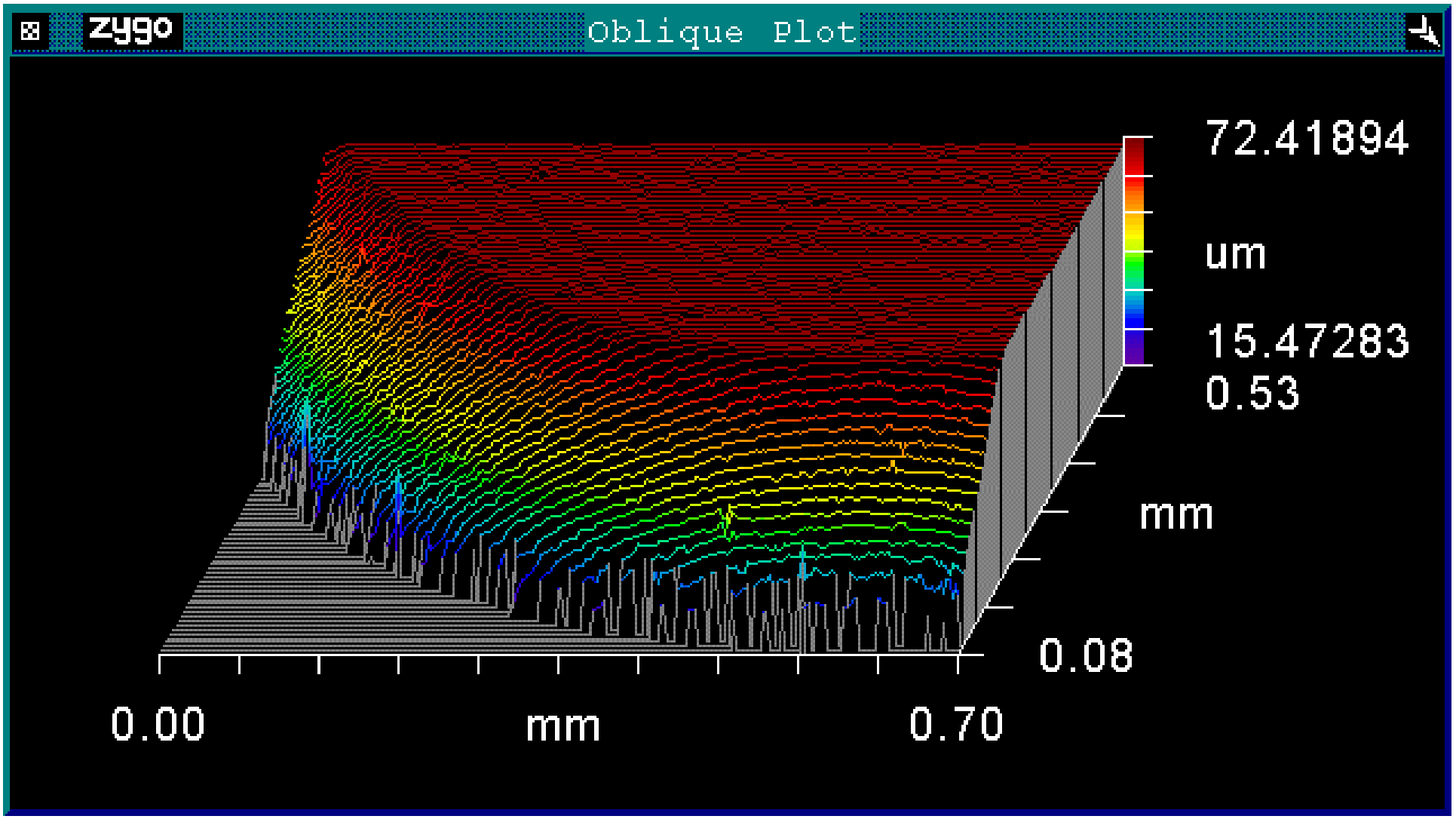


- Edge preparation has been shown to be a factor in hard turning
- Crater affects this cutting edge geometry
- This is particularly true for hard turning, where depths of cut are so small

Crater Wear



Progression of Crater Wear



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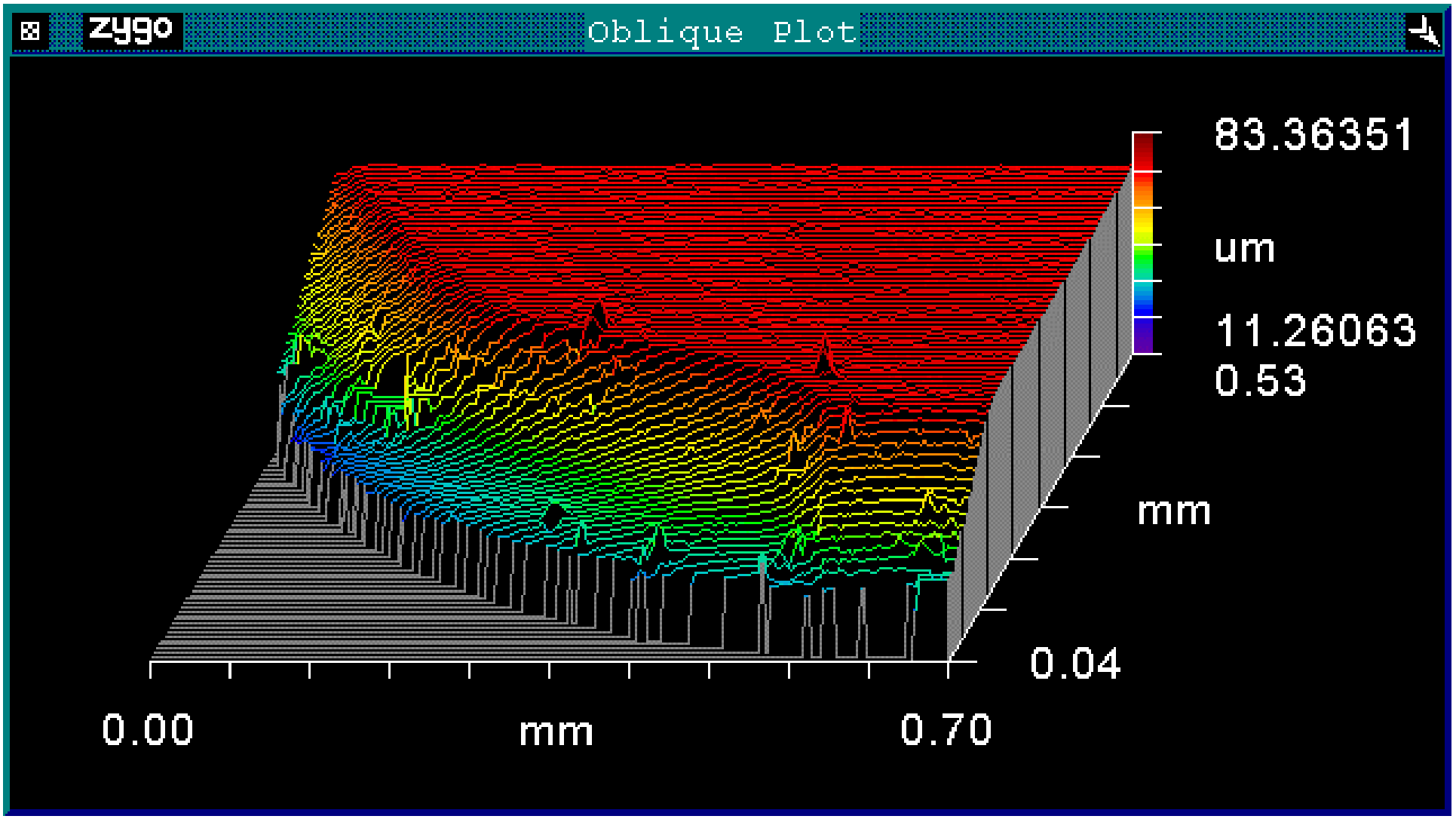

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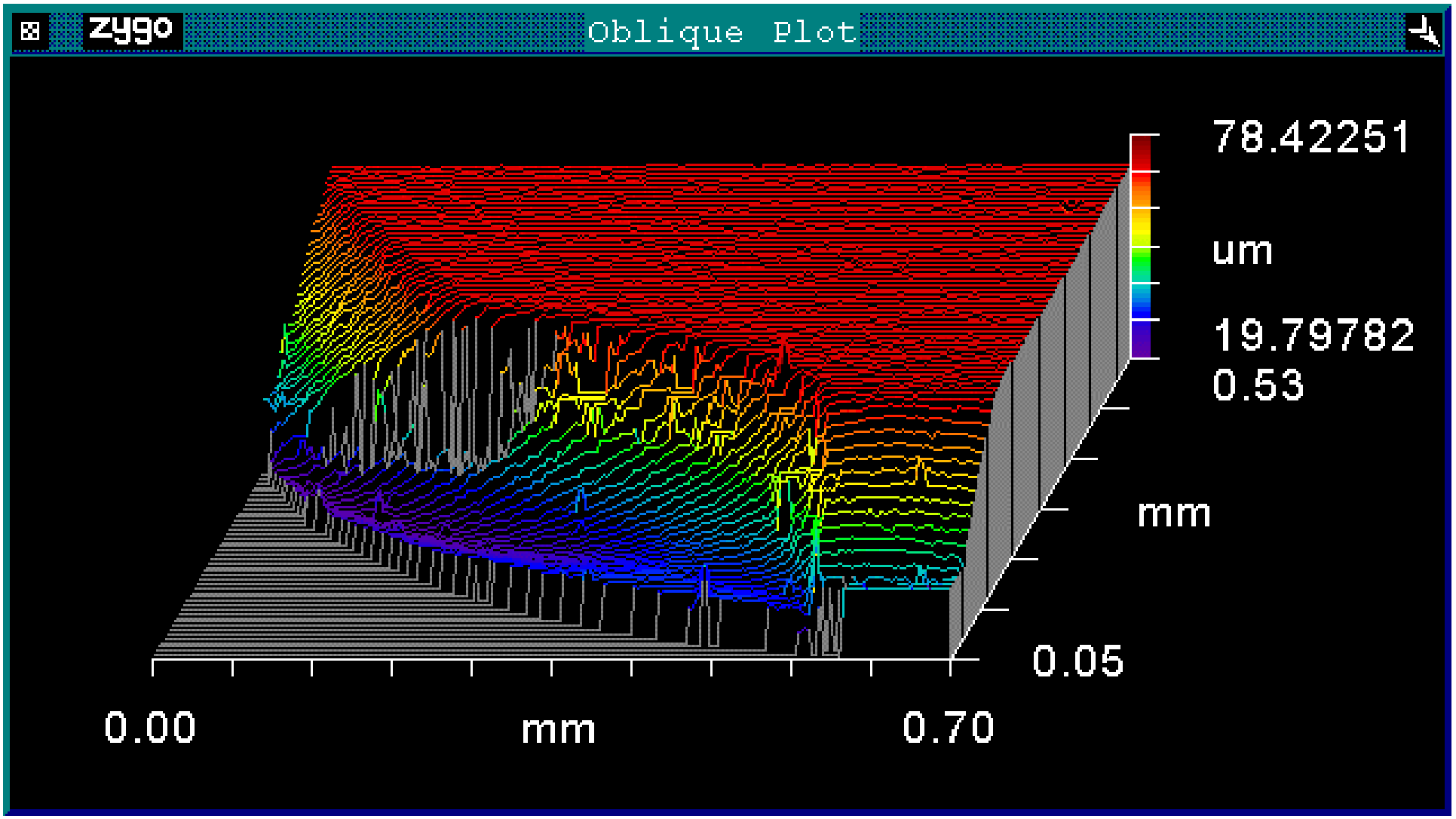

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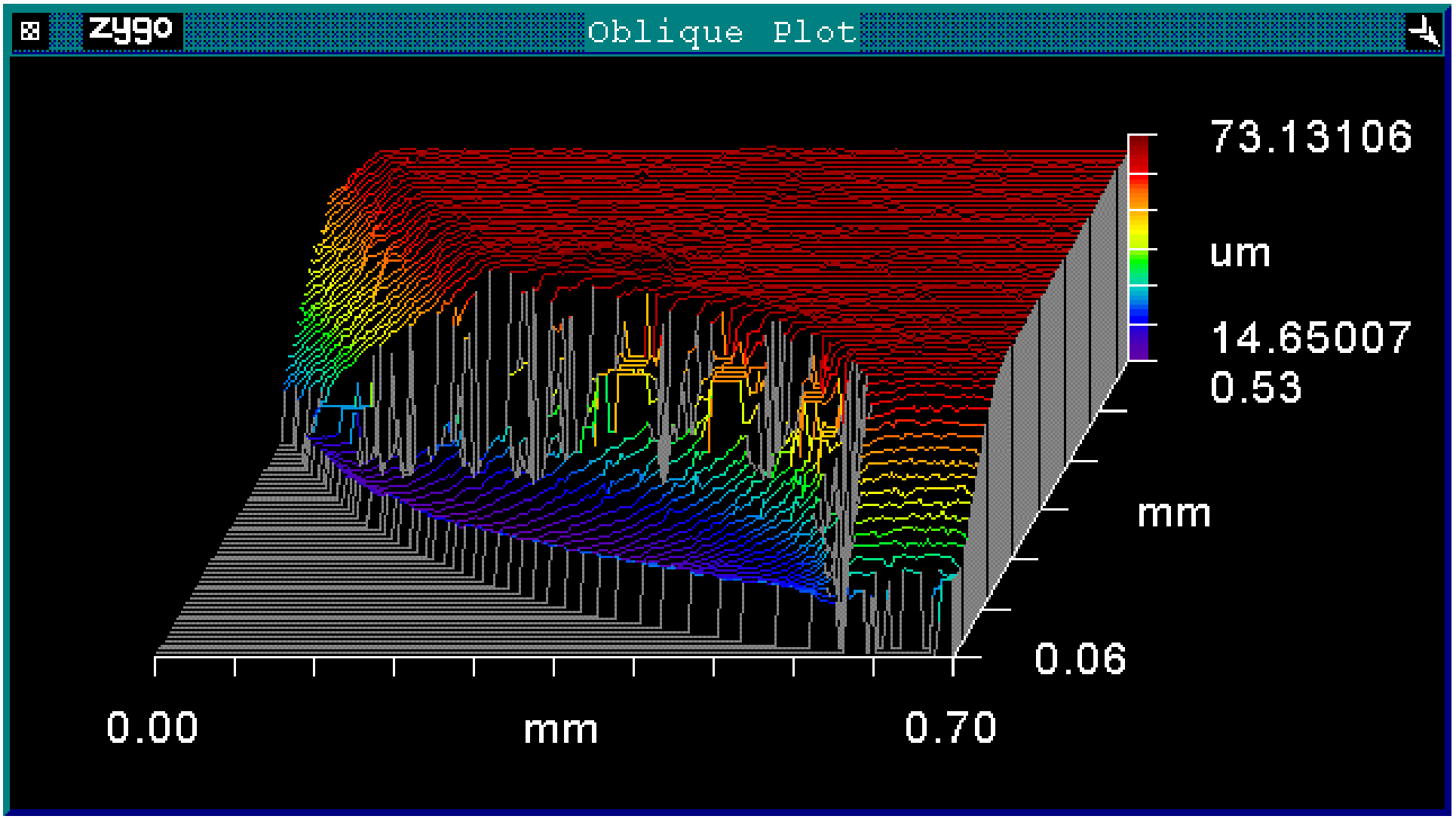

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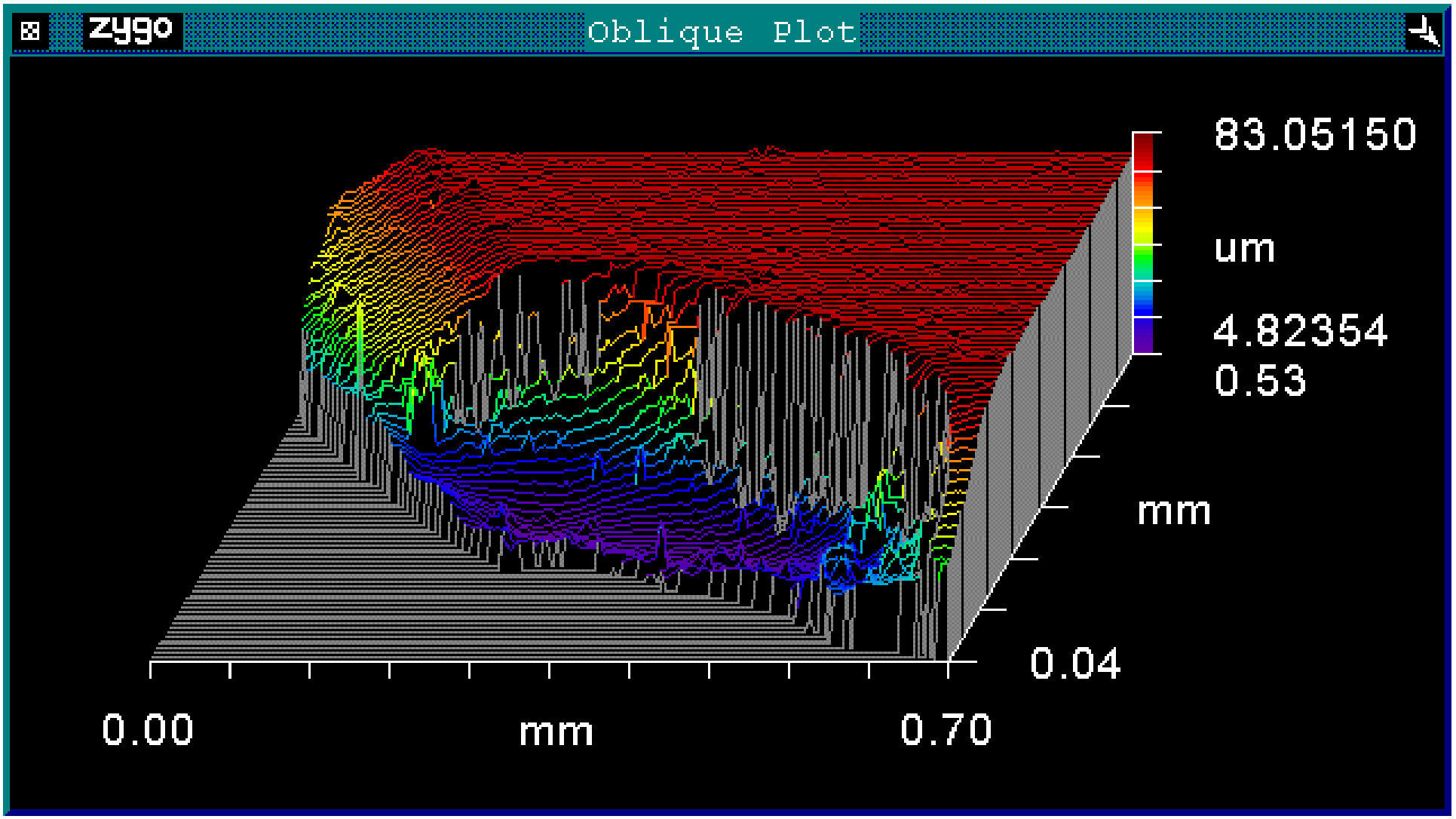
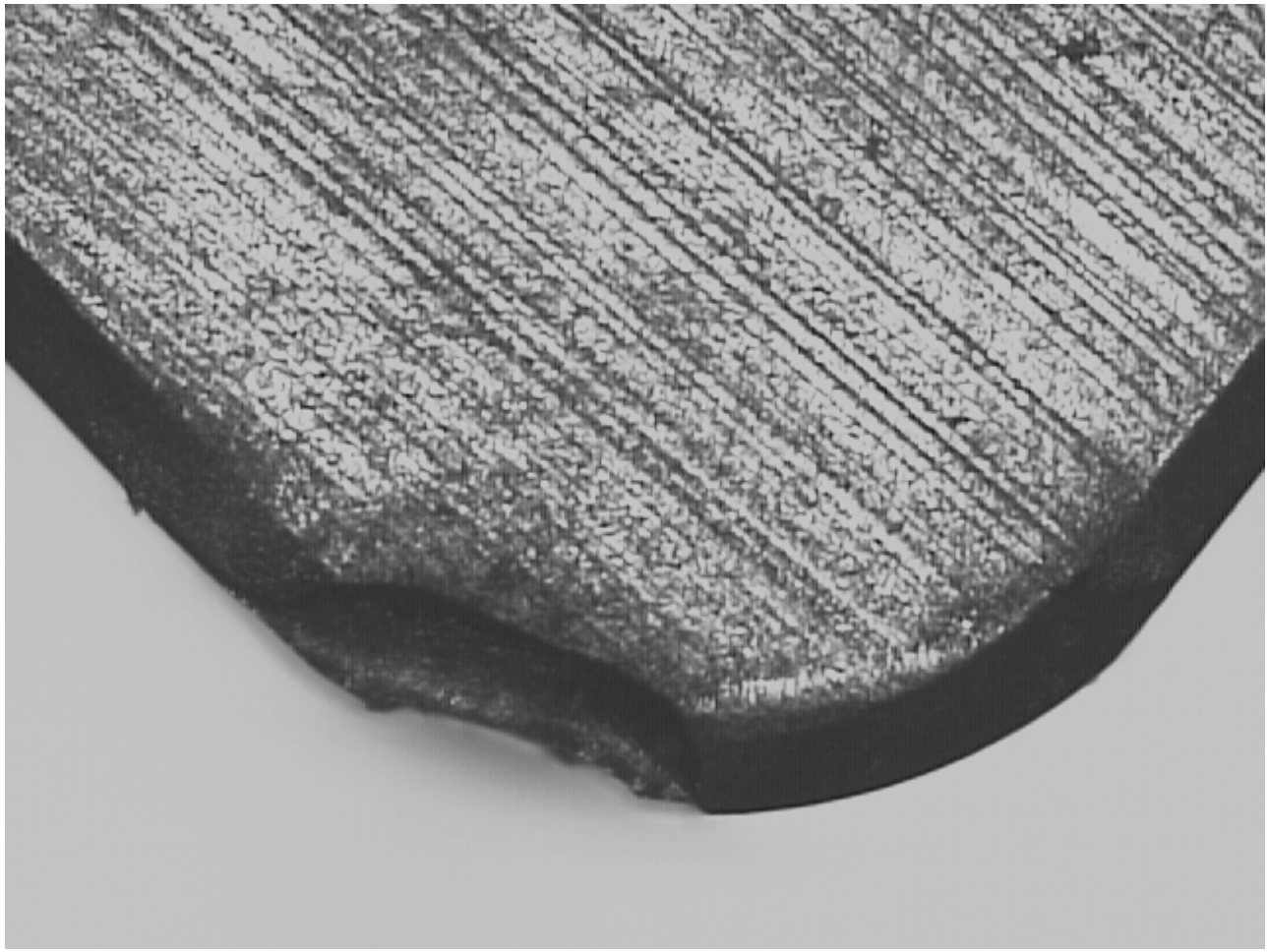
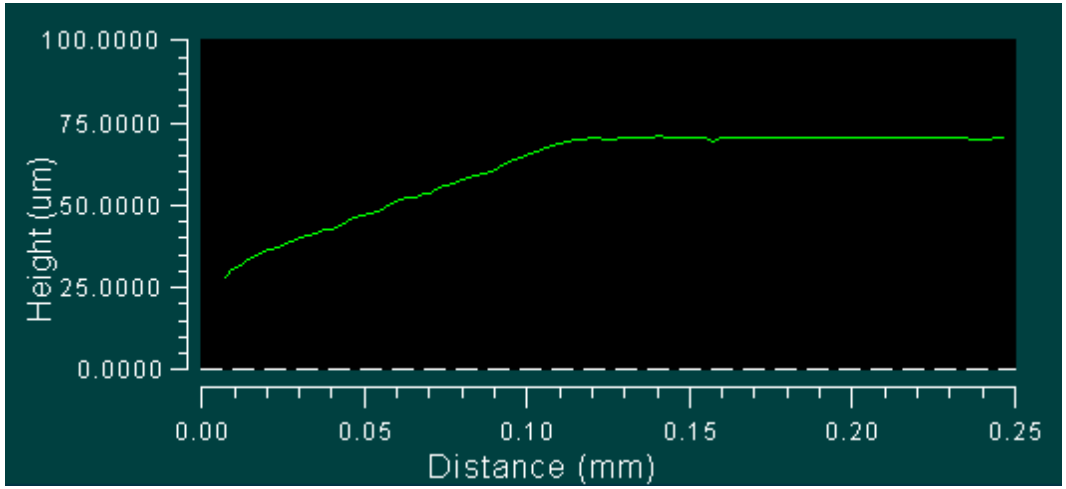


Tool Failure

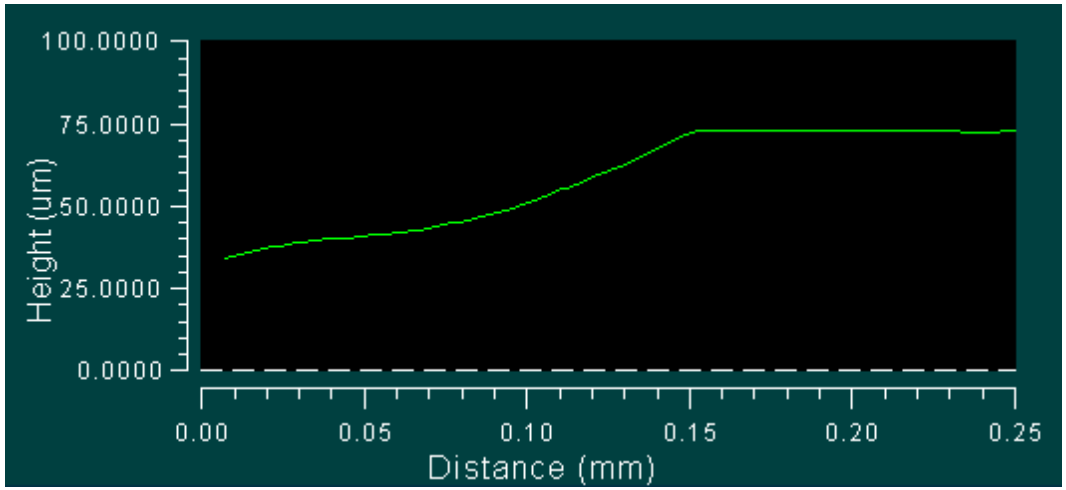


Changes in Cutting Edge Geometry

New Tool

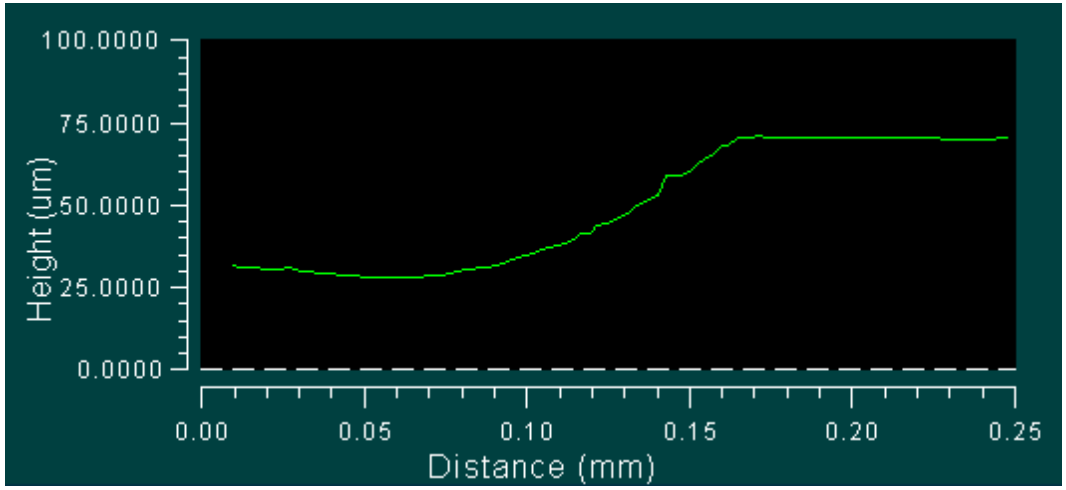


Pass10

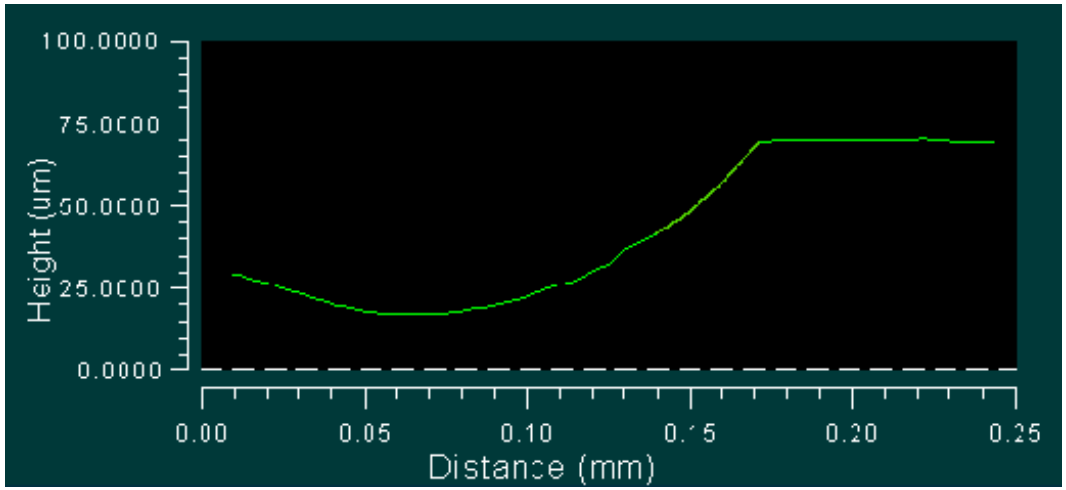


Changes in Cutting Edge Geometry

Pass20

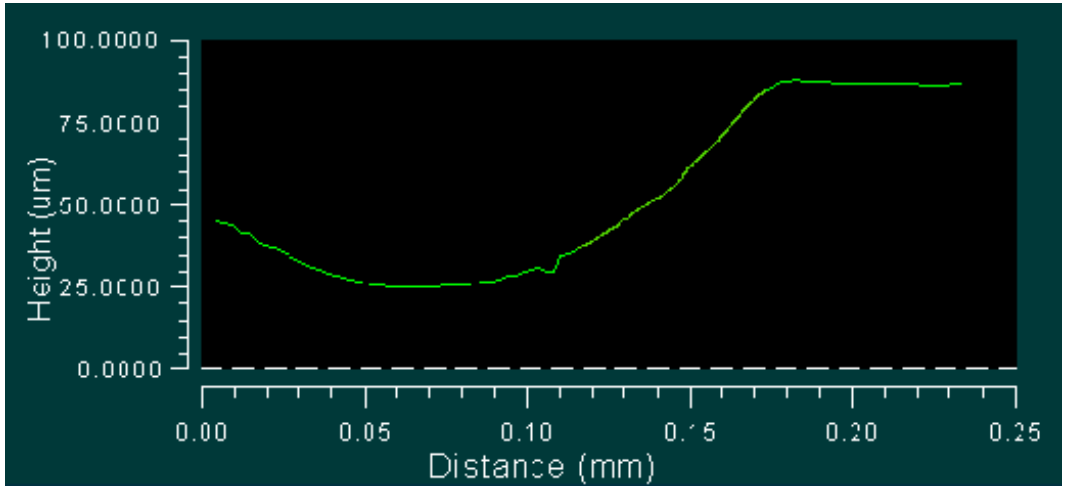


Pass30

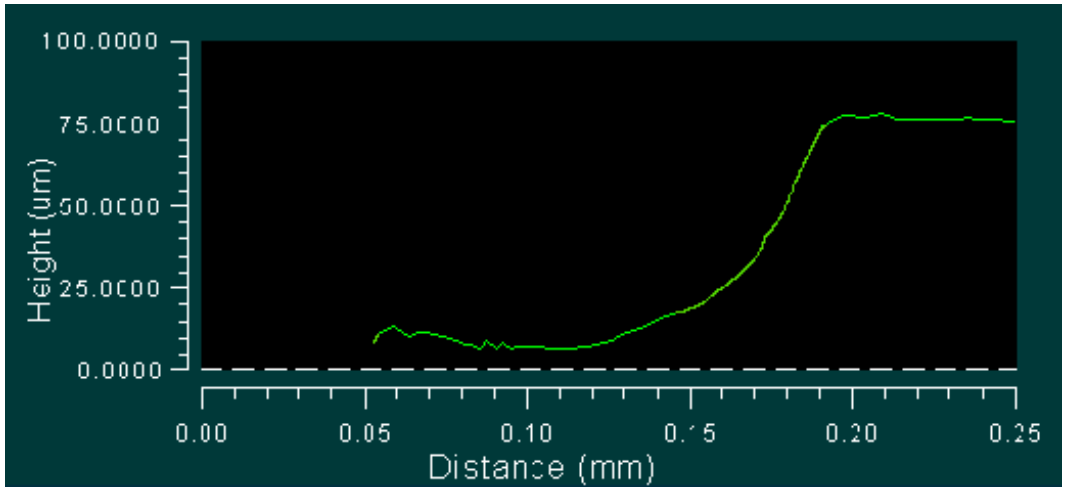


Changes in Cutting Edge Geometry

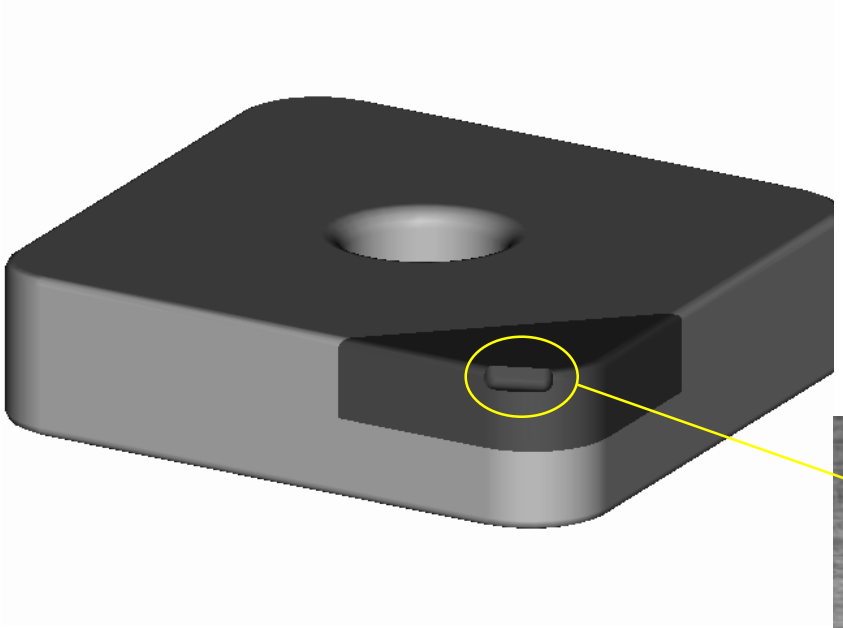
Pass40

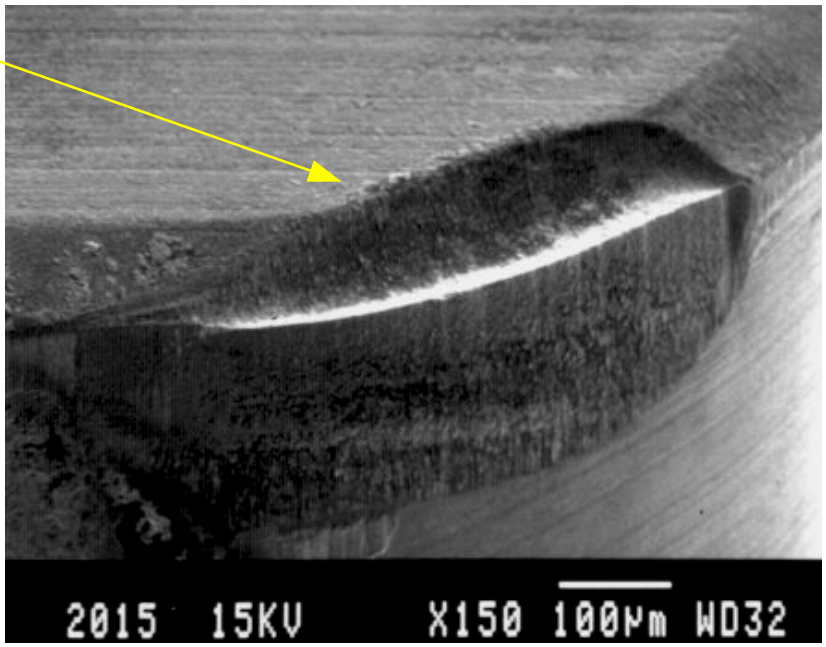


Pass50

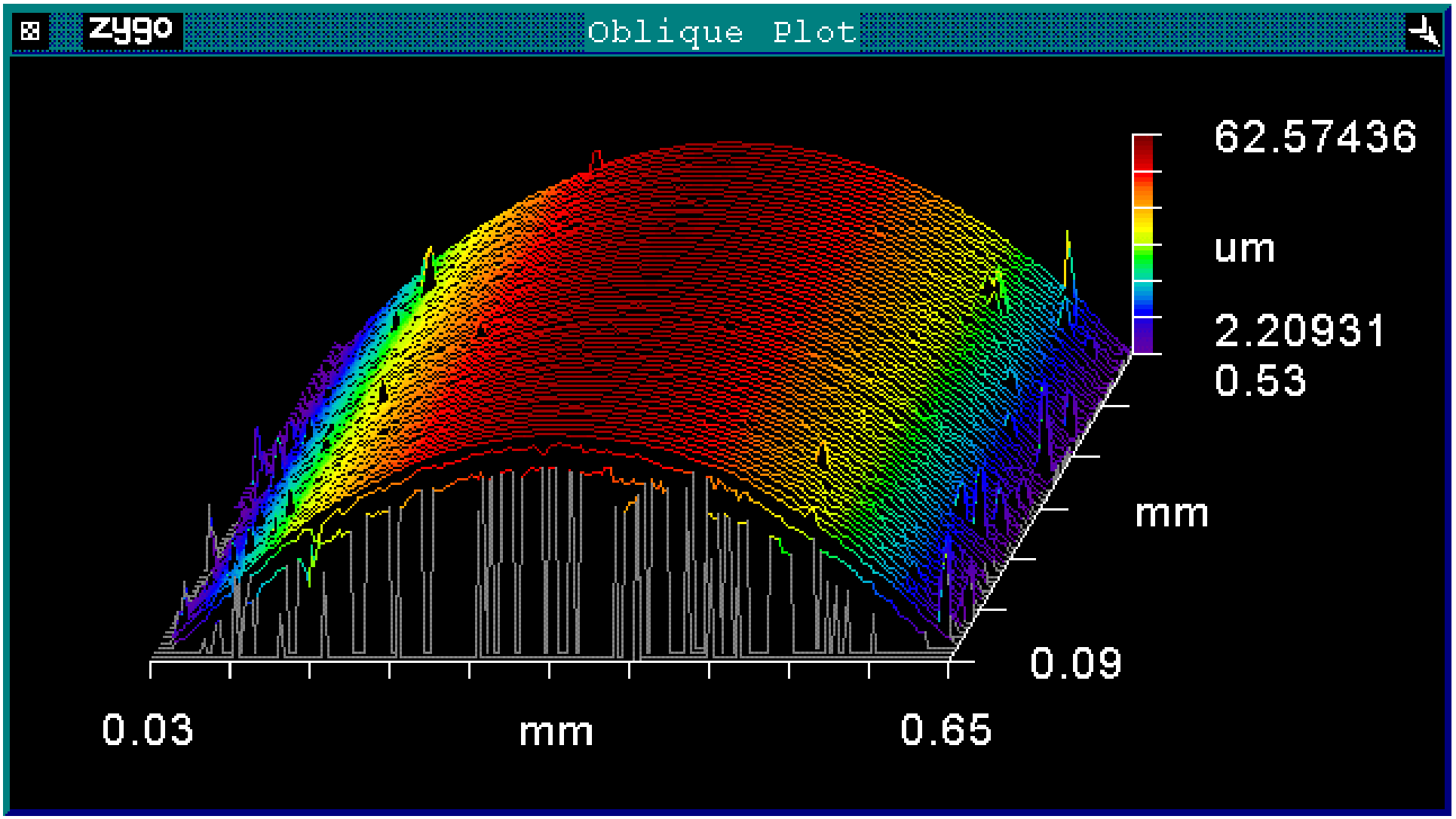


Flank Wear





Progression of Flank Wear



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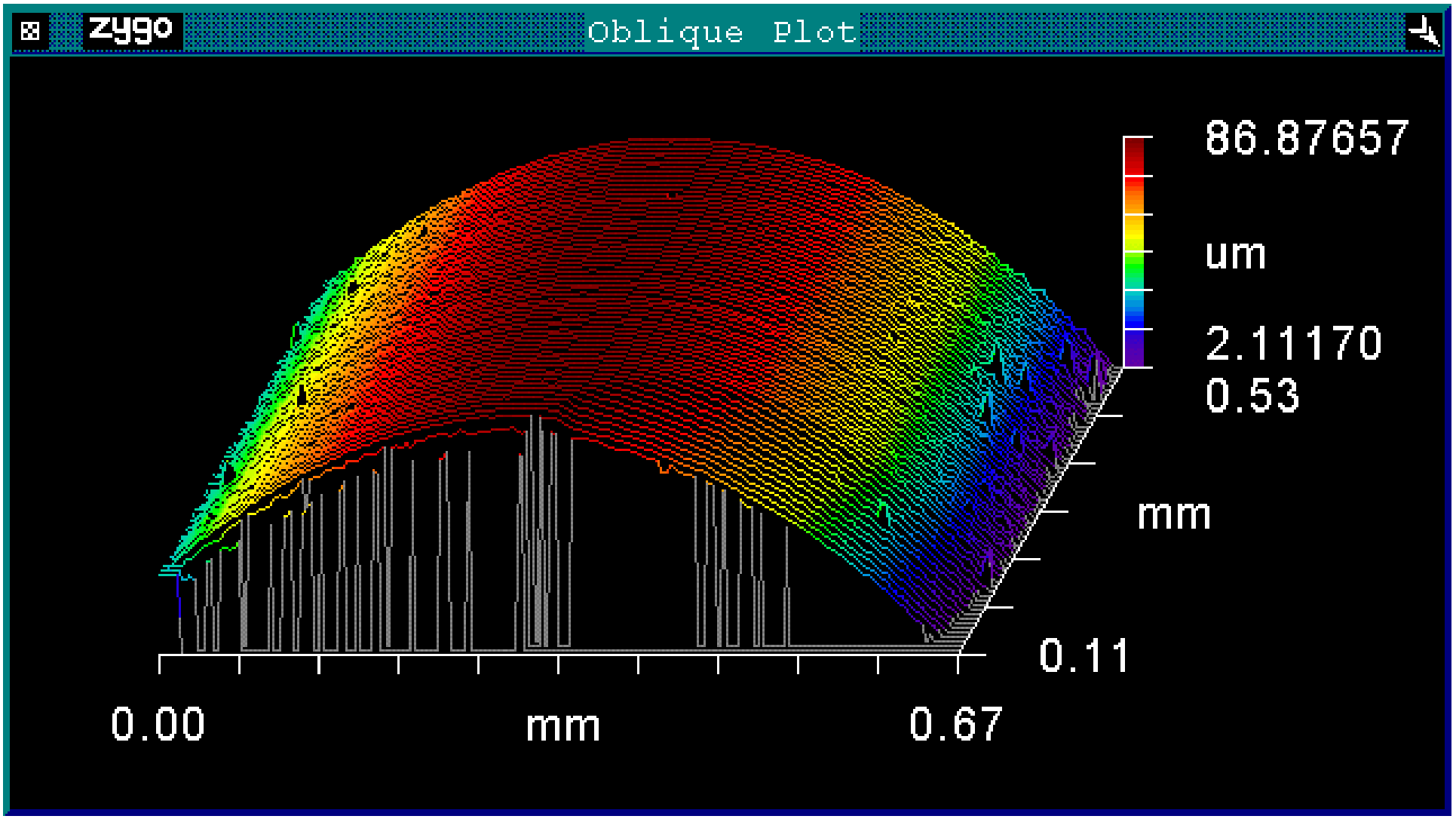

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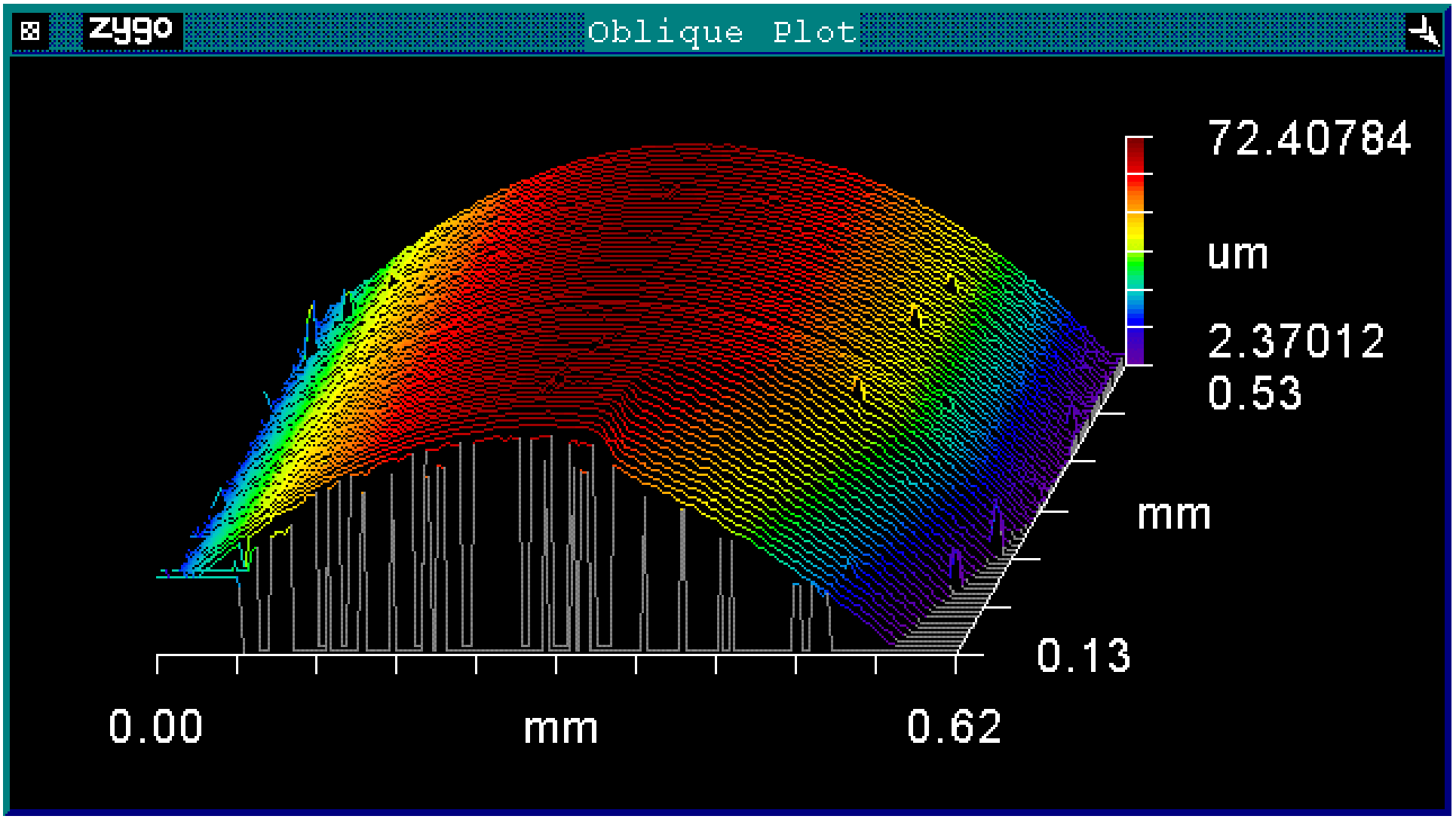

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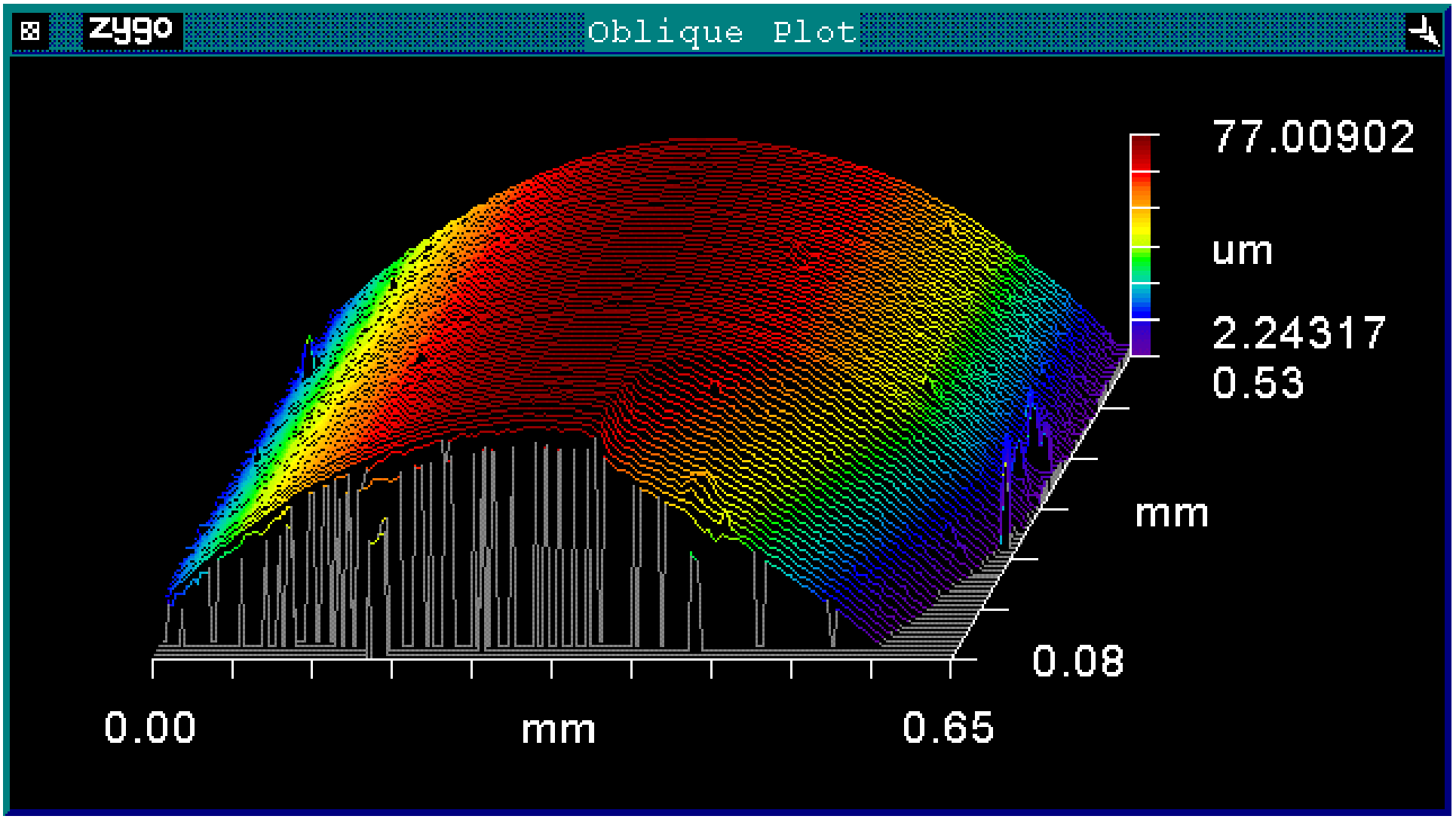

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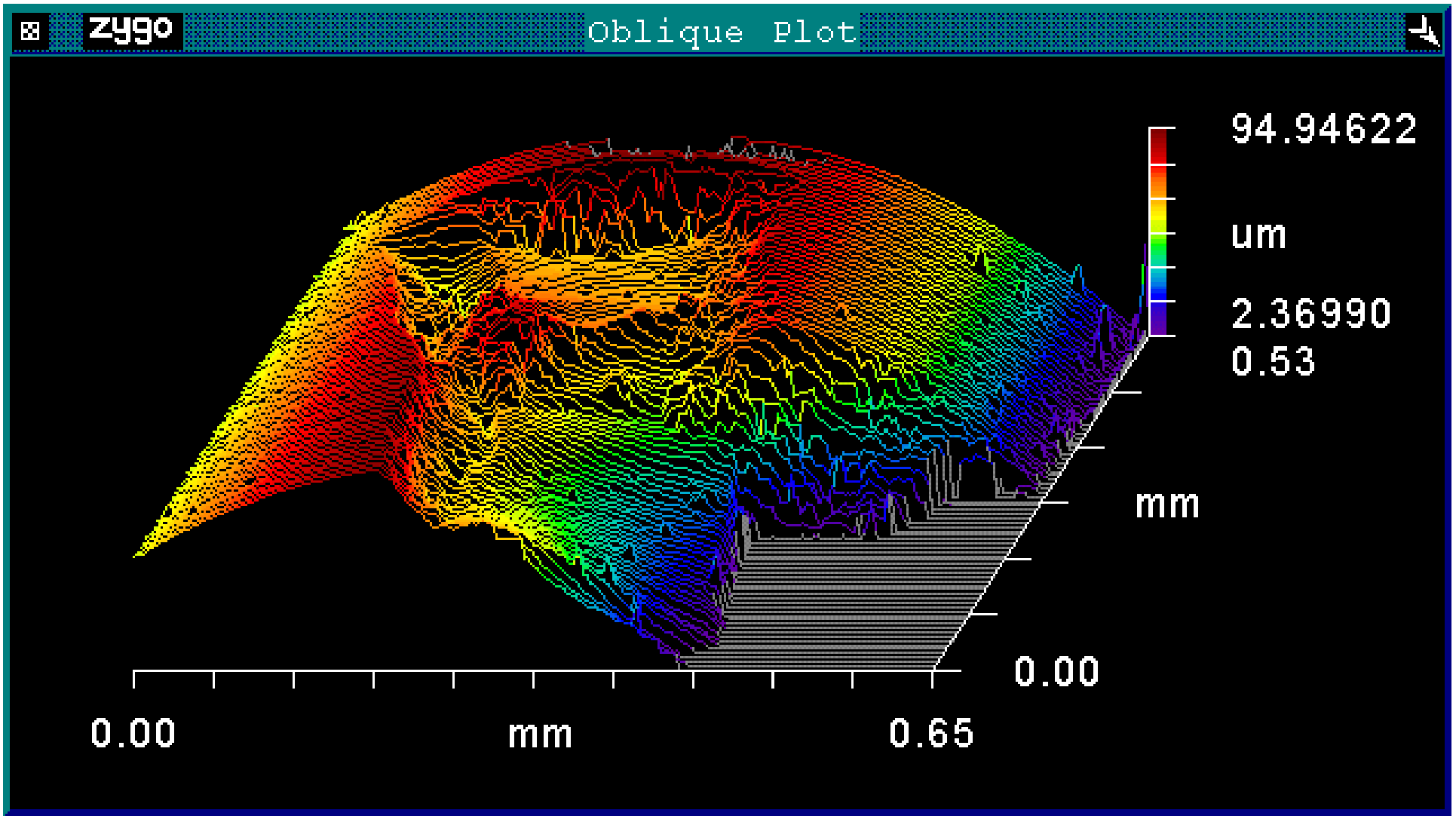
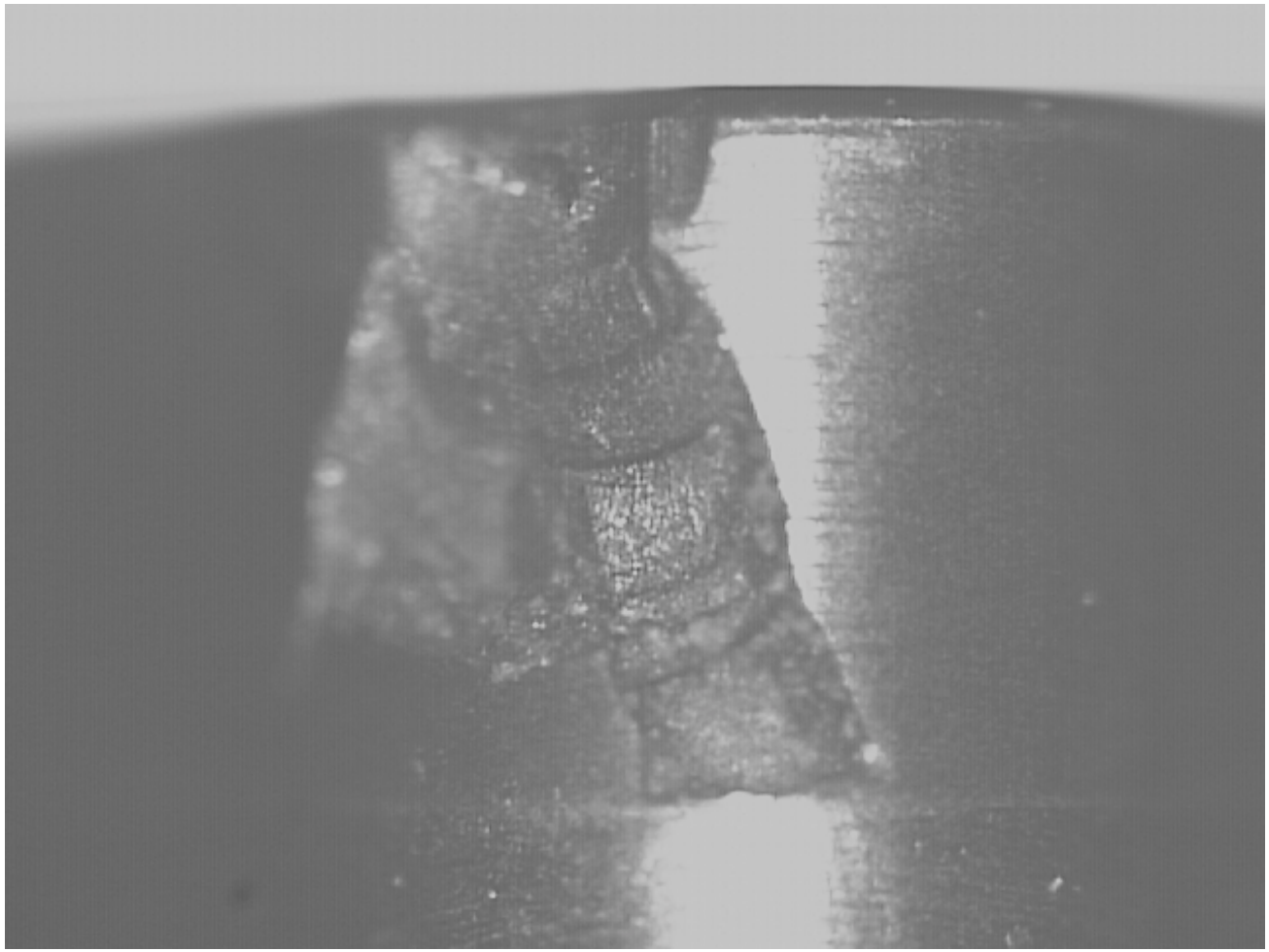
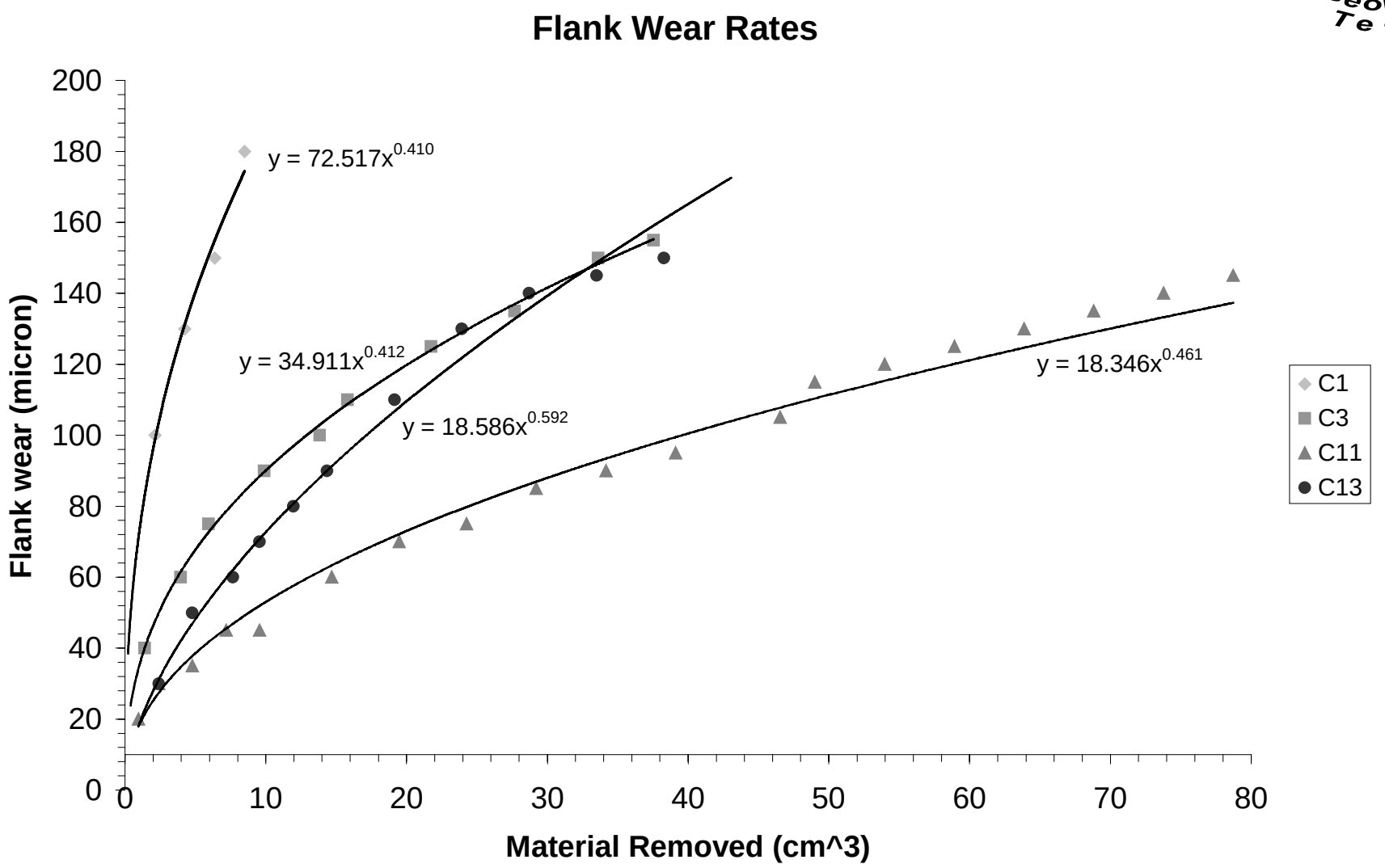


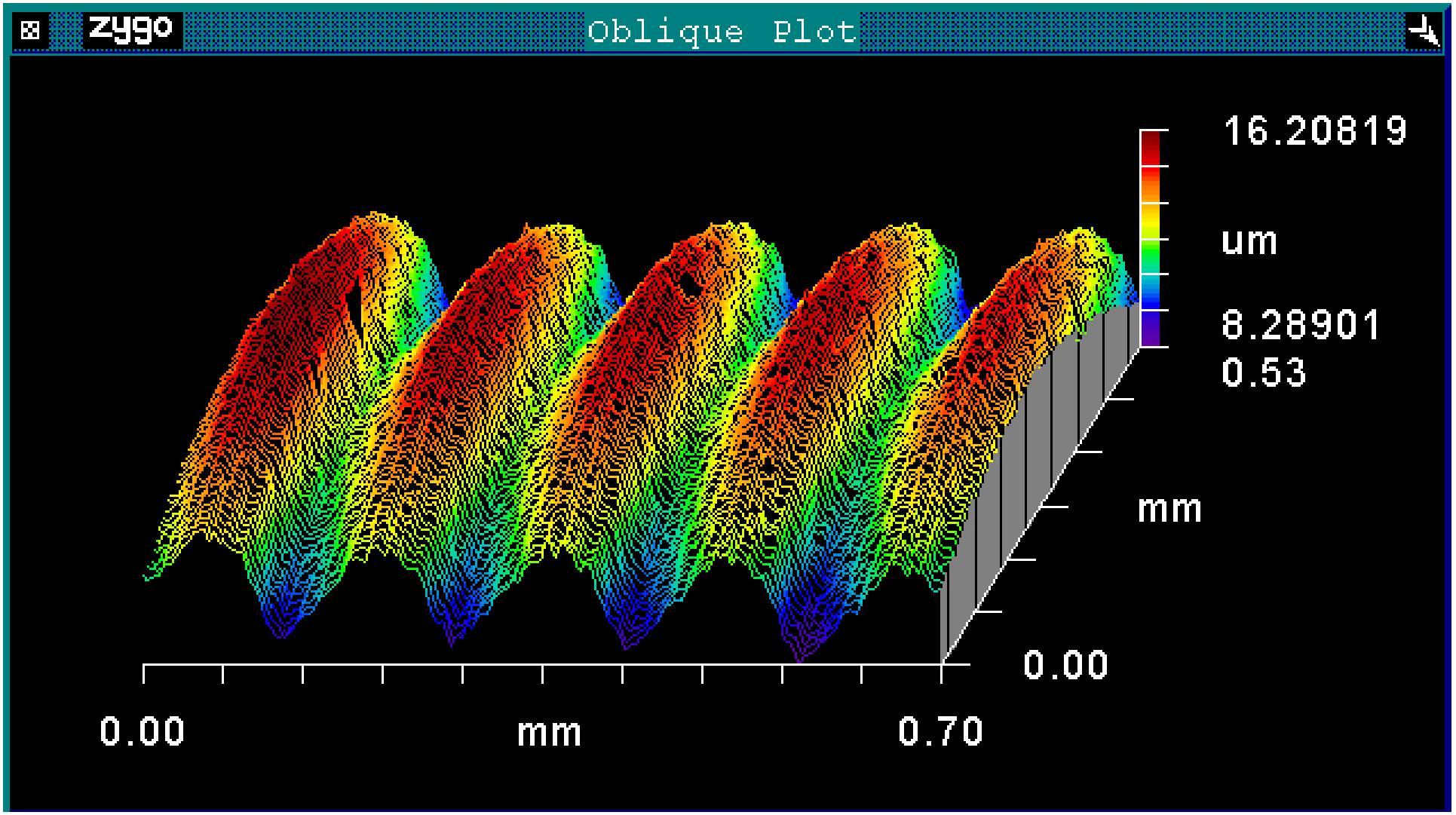
Tool Failure



Rate of Flank Wear

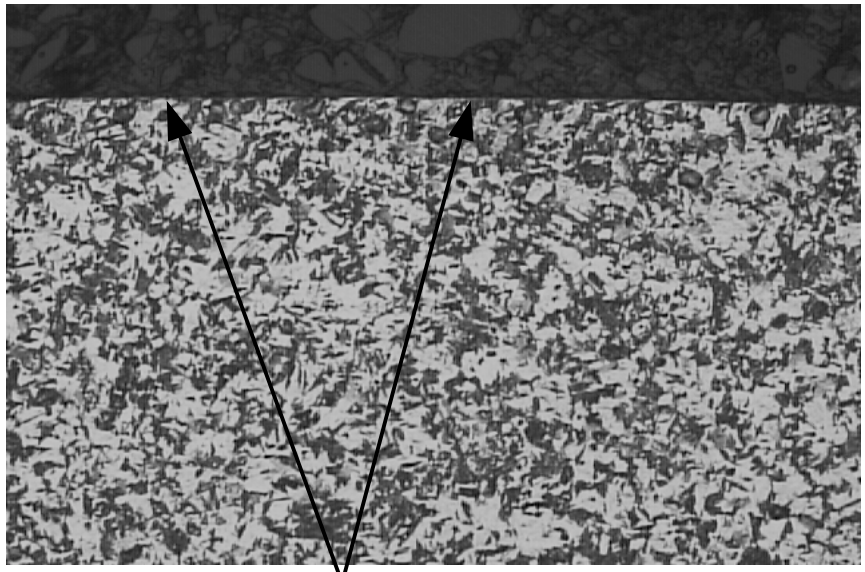


Surface Finish, Low Feed

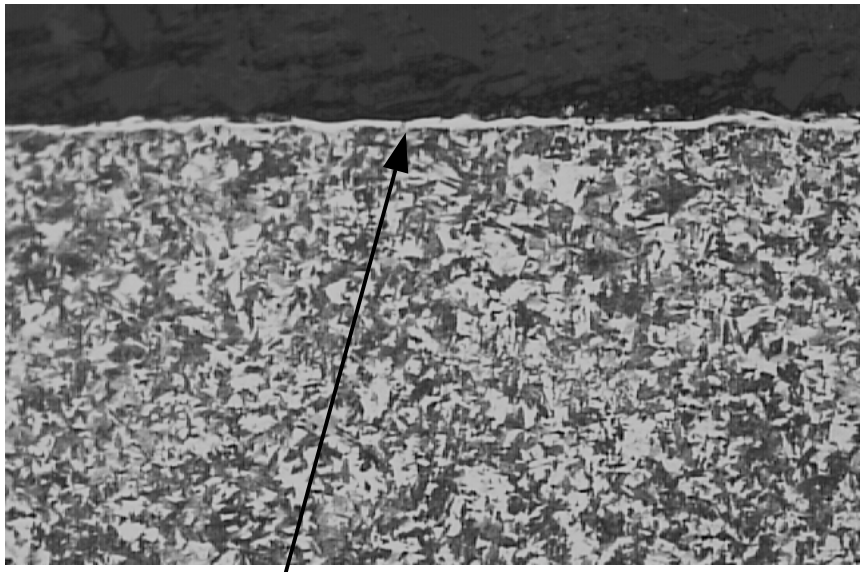


Microstructure Analysis

Turned Surface



EDM Surface



Conclusions

- Tool Wear
  - The Zygo New View 200 provided a very powerful method for monitoring both crater and flank wear
  - Because edge preparation is known to affect cutting results, a qualitative understanding of changes due to crater wear must be important
  - Changes in cutting geometry due to crater wear were shown
  - Maximum flank land for all conditions was found to be approximately 150 to 200 microns at failure
  - A power-law relationship was found between flank wear and volume of removed material
  - The cutting conditions change the coefficient of this equation, which could provide a powerful method for determining tool life

Conclusions

- Surface Roughness
  - Measured values match theoretical for larger feed rate
  - Smaller feed rates do not match well, but has been explained in past research as a result of increased plowing action
  - Tool wear improved roughness for most conditions due to flattening of the nose radius
- Surface integrity
  - Thermal damage (white layer) was found on all EDM surfaces and surfaces machined with low CBN content tools
  - No significant damage was found on any surface turned with high CBN content tools
  - High content CBN tools have increased thermal conductivity--resulting in less heat into the workpiece